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Water Samples of Soluble Nitrogen Determination in the McLeod Lake Traditional Territory

Prepared for:

Canadian Forest Products Ltd.
5162 Northwood Pulpmill Road
Prince George, BC
V2L 4W2



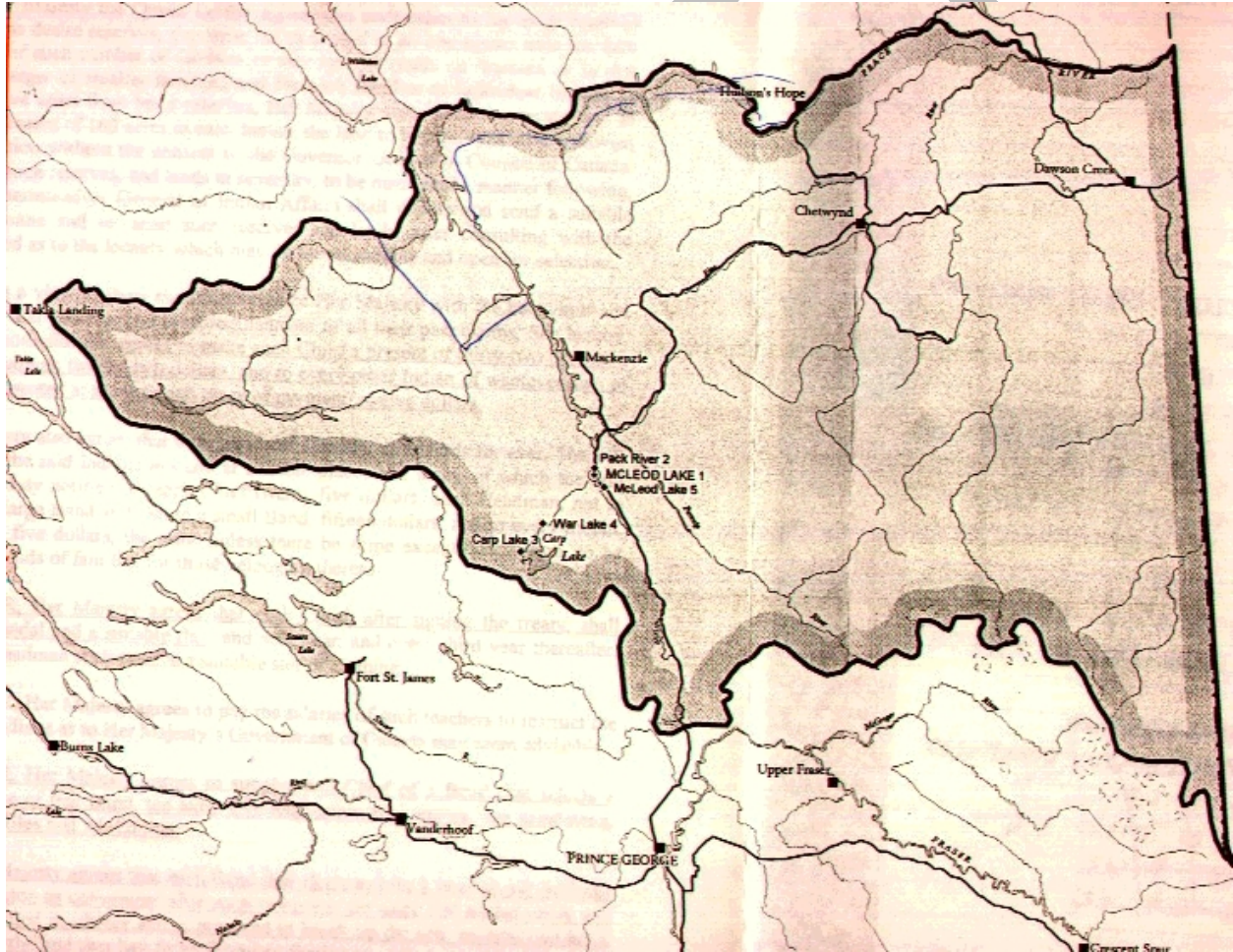
Prepared by:

Crawford Young, R.P.F.
Spectrum Resources Group Inc.
3810 - 18th Avenue
Prince George, B.C. V2N 4V5
Canada V1G 1N7

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Macleod Lake First Nation Traditional Territory

Picture taken from: www.mcleodlake.org/TraditionalTerritory.html

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INTRODUCTION

Located in the Tse'Khene Territory, there are a number of cultural, environmental and economic resources of significant importance. Within the economic sector, there are mining, fishing, and forestry interests. Within the environmental sector, there are many traditional and recreational uses of the forest resources and efforts (current or forthcoming efforts?) of many parties to maintain the intrinsic values of the area. It is in all parties' interests to preserve the area for wildlife and the traditional activities of the *People of the Rock*, and any future economic activities. In order to avoid any foreseeable impacts to the landbase, Canadian Forest Products Ltd. (Canfor) in its role as one of the stewards of the landbase, must work with First Nations and potentially impacted communities to achieve this. This is an example of how Canfor is working with the McLeod Lake Indian Band (MLIB) to ensure that their concerns over the protection of the water resource, which includes important fish habitat and their associated tributaries along the headwaters of the Fraser River, are being recognized and addressed.

Within the McLeod Lake Indian Band Traditional Territory, Canfor also has many interests, one of which is timber management. The Prince George Timber Supply Area (TSA 24) is facing a mid-term timber supply fall down in the wake of accelerate harvest rates due to the salvage of Mountain Pine Beetle, *Dendroctonus ponderosae*, impacted stands. This is a current incentive for undertaking a forest fertilization program in TSA 24. The Ministry of Forest and Ranges objective is to increase mid term timber supply and improve timber quality during an imminent period of timber shortage resulting from pine mortality caused by the mountain pine beetle and by fertilizing upwards of 130,000 hectares of spruce and Douglas-fir over the next five years. It's estimated this will add two million cubic metres of wood fibre over the next 10 to 15 years, while maintaining and enhancing other forest resource values. A range of incremental silviculture tools are available to accomplish this objective, the use of forest fertilizers applications focused on White Spruce and Douglas fir leading stands between the ages 15 to 80 years of age is one of the tools available to Canfor to help accomplish this objective.

Fertilizers have been used safely in B.C. for about 30 years. Strict rules govern fertilize usages. Fertilizers are not applied near streams or water bodies and extra care is taken so fertilizer is not eaten by wildlife or livestock. Forest fertilizers increase the amount of nutrients available to trees and therefore improve the growth rate and health of trees in certain conditions. However, nutrients from fertilizers such as nitrates are unwanted inputs to any nearby water bodies and/or watercourses, such as creeks, streams, wetlands and lakes. The Forest Fertilization Guidebook indicates "Water quality sampling is required in community watersheds and should be done when fertilizing near fisheries-sensitive zones. Samples should be taken before, during, and after treatment" (Forest and Range Practices Act, 1995). As a result, the BC Ministry of Forest has regulations governing allowable "Water Quality Limits" which ensure that application of fertilizers do not impact water bodies or watercourses. The following "Water Quality Limits" are placed on fertilizer treatments that occur adjacent to waterbodies and watercourses: "nitrate nitrogen levels in the stream exceeding 10 parts per million if measured immediately below the area where the fertilizer is applied" (Forest Planning and Practices Regulation, 2009). All licensees and

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others must abide by the regulation and not impact water bodies, watercourses or community watersheds.

To ensure that treatments do not impact waterbodies and/or watercourses during aerial fertilizer applications, mandatory “buffers zones” are established and maintained along all waterbodies and watercourses to prevent the accidental release of fertilizer into streams, lakes and wetlands. Canfor, as the licensee representative for implementing forest fertilization in the PGTSA made a commitment to the McLeod Lake Indian Band to collect water quality samples before, during and after fertilization treatment and analyze the levels of nitrate nitrogen from water bodies and watercourses that are adjacent to or are found within a fertilizer treatment group as a requirement for fertilizer treatment to occur within the McLeod Lake Indian Band Traditional Territory.

OBJECTIVE

The objective of this project is to document and ensure that Water Quality Limits, set out in the Forest Fertilization Guidebook and the Forest Investment Accounts Fertilization Standards are not exceeded by the aerial application of fertilizer during the 2007/2008 Aerial Fertilizations Project in the McLeod Lake Indian Band Traditional Territory. This was done by undertaking the collection and analysis of water quality samples on applicable treatment groups in the project’s 2007 treatment prescription. This report provides findings and discusses the results of the analysis on the water quality samples collected before, during and after the fertilizer treatment application in 2007/2008 in the McLeod Lake Indian Band Traditional Territory.

The Forest Fertilization Guidebook states “Water quality sampling is required in community watersheds and should be done when fertilizing near fisheries-sensitive zones” (Forest and Range Practices Act, 1995). Canfor has undertaken the water quality monitoring as a show of good faith as a way of going above and beyond these standards as stated in the guidebook.

Water sample labels, locations, characterizations and sample dates are all listed in Appendix A. Water samples taken but not treated are listed in Appendix B. It was our objective to take enough samples to get an accurate indication of the effect of fertilization on water quality. The sampling was not intended to include 100% of all water bodies in the area although most water bodies adjacent to the treatment areas were targeted. Water quality monitoring was also not intended to monitor fertilization accuracy. No inference was given to the accuracy of the treatment versus Nitrogen levels. Many conditions can affect the levels of nitrogen in the water and such an investigation, which would require a different methodology.

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METHODOLOGY

The technical department at Spectrum Resources Group Inc. was contracted to carry out the water quality sampling of water bodies and watercourses that surround or are within the Treatment Group polygons that were aeriually treated with fertilizer. The Nitrogen being applied to the Treatment Groups in this program is the standard forestry grade urea fertilizer (46-0-0 blend, (approximately 3–5 mm prill diameter)). The chemical formula ($\text{CO}(\text{NH}_2)_2$) is currently the only nitrogen fertilizer predominantly used in B.C. for operational applications. The target application rate was 200 kg/ha N, which is 435 kg/ha of urea fertilizer that was applied.

Selection of the sample points within the treatment groups were done according to the Forest Fertilization guidebook. That is to say each site is predetermined in the office on a map then confirmed in the field. The selection of one upstream location on streams served as a control. The other site selected downstream served as the treatment area sample and also served as an indicator of maximum concentration of chemicals due to the fertilizer application. Accurate location tracking and comparison of control and treatment sites gives the best indication of nitrogen fluctuation.

Recommendations and guidelines for undertaking a water quality monitoring program as outlined in Forest Fertilization Guidebook were followed. It should be noted that no fertilization applications made during the undertaking of this project occurred in a community watershed or in any contentious or fisheries-sensitive areas. This water quality sampling was undertaken to meet a commitment to the MLIB.

CAPTURE OF FIELD SAMPLES

The water quality sampling was completed 2 weeks prior to treatment, during treatment and after treatment.

Forest technologists confirmed the locations of the actual water bodies and watercourses, prior to treatment in the field. Two (2) sampling sites, one upstream from the treatment area serving as the control and the other immediately downstream of the treatment area are chosen. Utilizing a Global Positioning System (GPS) the water quality sample location was recorded and marked in the field and a water quality sample was collected. This methodology allows for quick and accurate relocation of the sample site during subsequent sample collections.

Forest technologists were provided with sterilized empty water bottles from the Research Branch Laboratory of the BC Ministry of Forests for the collection of the water quality samples. The sample bottle is rinsed several times with the stream water, then the water samples is obtained as close to mid-stream and mid-depth as practically possible, filling the sample bottle completely., The bottle is then capped, labelled, frozen and stored for shipping.

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Each bottle was labelled individually. Labels included the date of sampling, the Treatment Group ID number, the water body or water course the water quality sample was collected from and the location with respect to the were in the water body the sample was collected from (upstream, downstream or within the treatment area).

Labelling of the points contains information on water body (S = Stream, W = Wetland or L = Lake), Treatment Group ID, location on the stream (U = upstream, D = downstream) and feature number (in case there is more than one lake being sampled in that treatment group).

SAMPLE STORAGE AND SHIPPING

The procedure for sample storage and preparation for shipping was conducted utilizing one of the two following methods.

The first storage method was to seal the bottles, then place the bottles in a cooler packed with ice (in order to maintain a sample temperature of approximately 4°C) and ship the bottles to the BC Ministry of Forests' research branch laboratory immediately (the samples must be received by the laboratory within 72 hours of collection).

The second method utilized was to freeze the sample bottles to preserve the water samples and then place the bottles in a cooler packed with ice and ship the samples to the BC Ministry of Forests' research branch laboratory. This methodology will allow samples to be collected over several days or weeks prior to being shipped to the BC Ministry of Forests' research branch laboratory and then approved by the Chemist/Special Applications technician from the Ministry of Forest, Dave Dunn.

LABORATORY HANDLING OF WATER SAMPLES

In Victoria, located at B.C. Ministry of Forests Research Branch Laboratory, the water quality samples were kept frozen at -80 C prior to analysis. Immediately prior to the analysis of the samples, the samples were thawed, shaken and filtered through a 0.45 um nylon membrane filter.

Urea breaks down/transforms to ammonium and nitrate. All forms of Nitrogen in the water quality samples collected were identified through chemical analysis. Levels of chemicals analyzed were:

- 1) Ammonium-N (NH_4) is the ionized form of inorganic N and is non-toxic in aquatic systems. This form of N can be taken up and utilized by the trees (Canadian Council of Ministers of the Environment [CCME], 2004)),
- 2) Nitrate-N (NO_3) can be readily taken up and used as a source of N by trees; it is also relatively mobile in soil and lost to streams). Soil temperature largely determines the rate of

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transformation from urea to ammonium to nitrate (Perrin, 1994). Nitrate can be a concern where concentrations are greater than 10µg/L (Binkley et al., 1999a)

- 3) Total N (Or Total ammonia ($\text{NH}_3 + \text{NH}_4$), a combination of NH_3 and NH_4 , which can exist in water, but NH_3 is only stable at pH greater than 9 (Binkley et al., 1999a).
- 4) Organic N (N-organic) Organic Nitrogen was determined as the difference between the total Nitrogen and initial inorganic Nitrogen concentrations (Binkley et al., 1999a).

IMPORTANT

The water quality samples were determined using an Alpkem segmented-flow, an automated chemistry analyzer.

Note: Increasing Nitrate (NO_3^-) and total ammonia concentrations in drinking H_2O are of the greatest public concern. Case studies have shown that fertilizer application result in short term increases in N (NO_3^- -N and Total ammonia) conc. to streams. Even when buffer zones are applied around waterbodies, they found a spike in nitrate-N and ammonium-N (Binkley et al., 1999a).

It should also be noted that fertilizer elements can be expected to move in surface drainage and unintentional nutrient transport to waterbodies is generally been found to not be enough to impair aquatic ecosystem health or affect the quality of drinking water (Pike et al., 2005).

Excess urea reaching water bodies is less of a concern than transport of total ammonia. Ammonia is highly mobile in forest soils. Excessive leaching of urea can occur during heavy rainfall if it has not been broken down into chemical forms that can be used by vegetation (Perrin, 1994).

Also we utilized buffer zones and studies have found that areas that did not utilize buffers have had the largest increase in N. This is why mandatory buffers and restrictions have been placed upon us.

Total soluble Nitrogen was determined by alkaline persulphate oxidation of all Nitrogen forms to nitrate, which was subsequently analyzed on the Alpkem analyzer.

After the chemical analysis was completed, mathematical formulas were used to determine the levels of Nitrogen that were classified as either Organic Nitrogen or Inorganic Nitrogen concentrations. The levels identified were quantified as parts per million (ppm); i.e., 1 part Nitrogen means that there was 1 part Nitrogen in 1 million parts of the sample.

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RESULTS

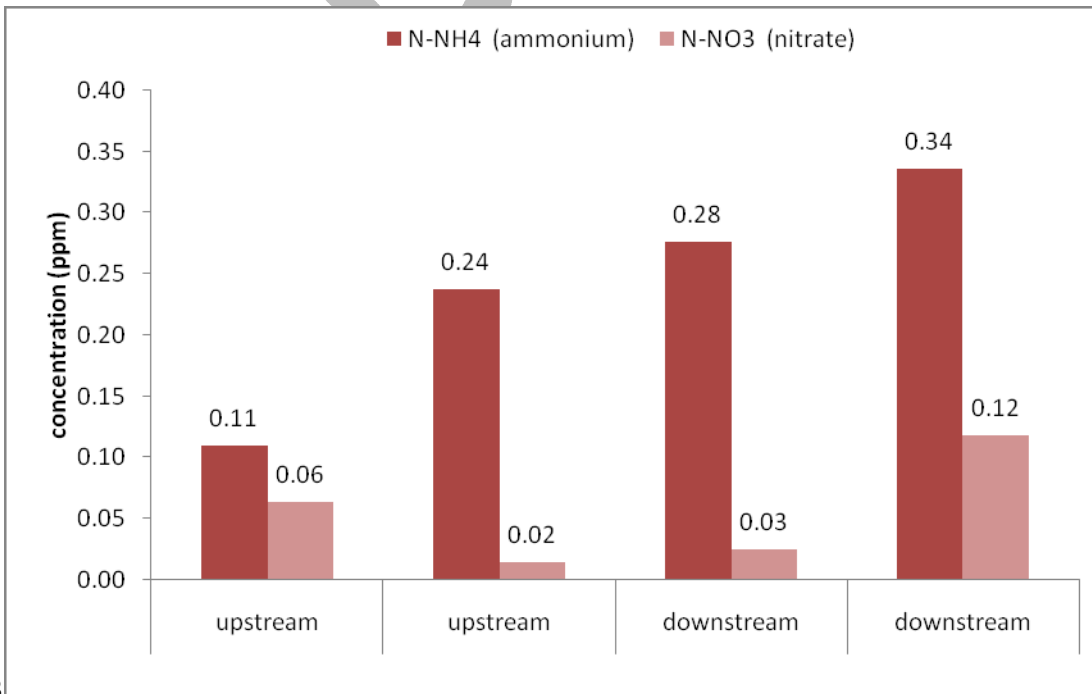
Originally, ninety (90) water quality samples were collected from fourteen (14) different treatment groups scheduled for fertilizer application during the 2007 program. Due to adverse weather conditions, the program was cut short and only seven (7) of the original 14 treatment groups were actually aerielly fertilized during the 2007 program. Of the seven (7) areas actually treated with fertilizer, there was enough data to provide statistical analysis for two (2) of the treatment groups. The results are presented below in a graphical format.

The other five (5) treatment groups have data showing nitrate and total nitrogen levels during and post treatment, as issues with label information being lost on pre treatment sample bottles precluded analysis. The during and post treatment nitrate and total nitrogen levels are presented in a table format, to verify that the water sample data collected from these five (5) sites did not exceed the BC Ministry of Forests regulation of inputting more than 10 parts per million nitrates levels, in the 3 weeks post treatment.

The two Treatment Groups presented in chart form are 210-589 and 303-94.

Treatment Group 210-589

Location: Creek



3

Figure 1 Concentration in parts per million of NH₄ and NO₃ in Treatment Group 210-589 upstream and downstream at Stream 3 during (November 8, 2007) and following (November 27, 2007) a fertilization treatment.

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(Note: dates are not shown on the chart. The first upstream and downstream bars were taken on November 8, 2007. The second upstream and downstream bars were taken on November 27, 2007.)

Analysis indicates that both upstream and downstream concentrations of NH_4 were higher following the application of fertilizer in stream 3. Upstream concentrations of NO_3 were higher during the application of fertilizer and lower following the application of fertilizer.

Treatment Area 210-589

Location: Creek 3

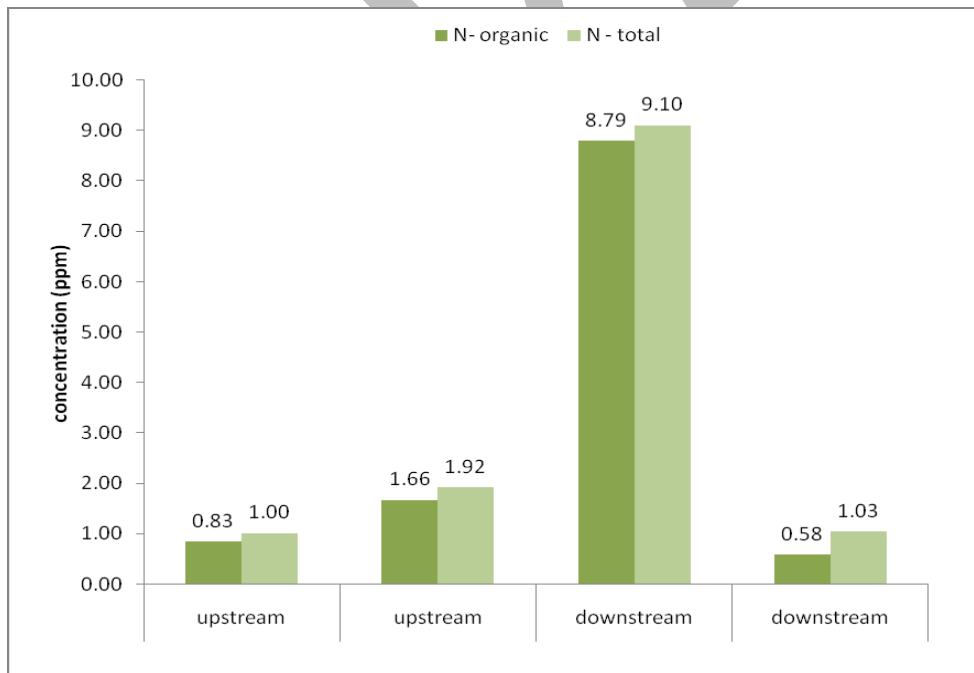


Figure 2 Concentration in parts per million of organic nitrogen and total nitrogen in Treatment Group 210-589 upstream and downstream at creek 3 during (November 8) and following (November 27) fertilization treatment

(Note: dates are not shown on the chart. The first upstream and downstream bars were taken on November 8, 2007. The second upstream and downstream bars were taken on November 27, 2007.)

Upstream concentrations of organic nitrogen and total nitrogen increased following fertilization. Downstream concentrations of organic nitrogen and total nitrogen were much higher during the application of fertilizer than they were a few weeks later.

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To be clear, figure 1 shows concentrations of NH₄ and NO₃ found in Creek 3 in the 210-589 treatment area. Figure 2 shows concentrations of organic nitrogen and total nitrogen levels found in Creek 3 in the 210-589 treatment area.

Treatment Area 303-94

Location: Creek 1

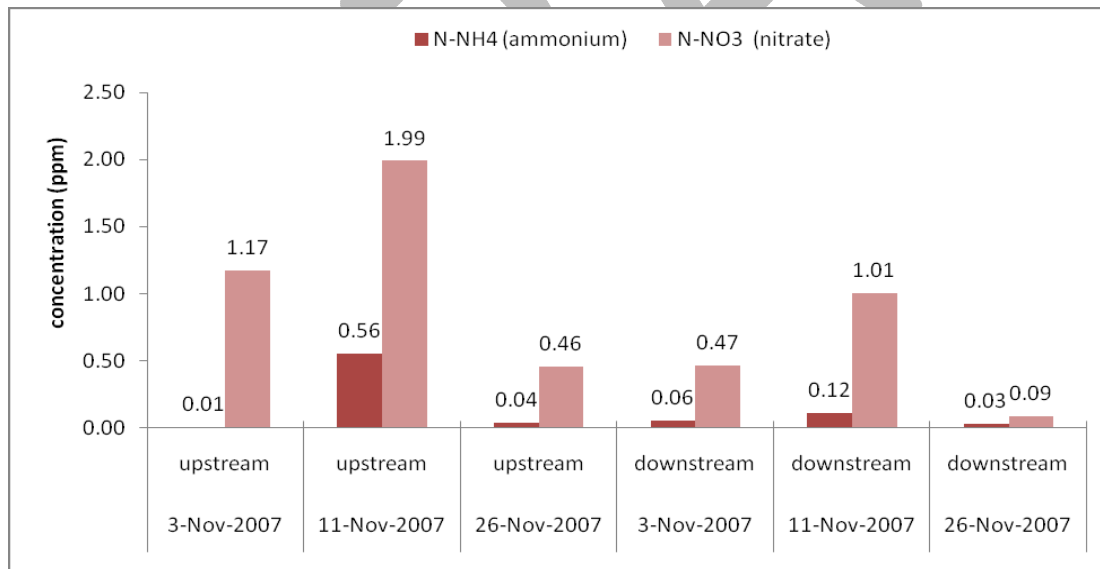


Figure 3 Concentration in parts per million of NH₄ and NO₃ in block 303-94 upstream and downstream at creek 1 prior to (November 3) during (November 11) and following (November 26) a fertilization treatment.

Upstream and downstream concentrations of NH₄ and NO₃ spiked during the application of fertilizer and returned to concentrations very near those prior to the application of fertilizer.

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Treatment Area 303-94

Location: Creek 1

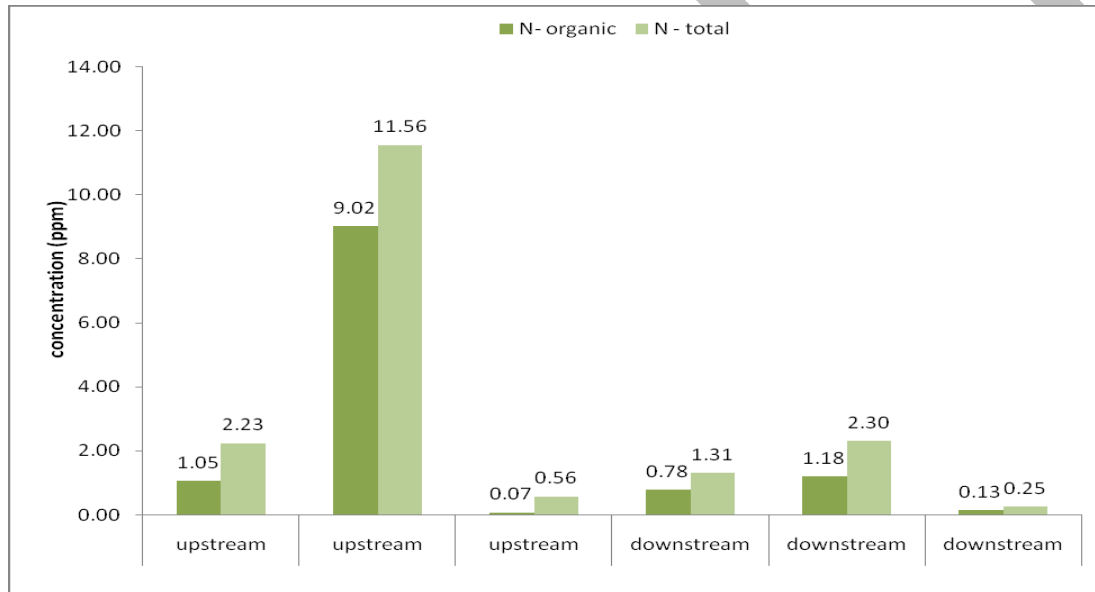


Figure 4 Concentration in parts per million of organic nitrogen and total nitrogen in block 303-94 at upstream and downstream at creek 1 prior to (November 3) during (November 11) and following (November 26) a fertilization treatment.

(Note: dates are not shown on the chart. The first upstream and downstream bars were taken on November 3, 2007. The second upstream and downstream bars were taken on November 11, 2007. The third upstream and downstream bars were taken on November 26, 2007.)

Upstream concentrations of organic nitrogen and total nitrogen spiked dramatically during the application of fertilizer and returned to low concentrations a few weeks later. Downstream concentrations of organic nitrogen and total nitrogen increased during the application of fertilizer and returned to low concentrations a few weeks later.

To be clear, figure 3 shows concentrations of NH_4 and NO_3 found in Creek 1 in the 303-94 treatment area. Figure 4 shows concentrations of organic nitrogen and total nitrogen levels found in Creek 1 in the 303-94 treatment area.

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Treatment Area 303-94

Location: Creek 2

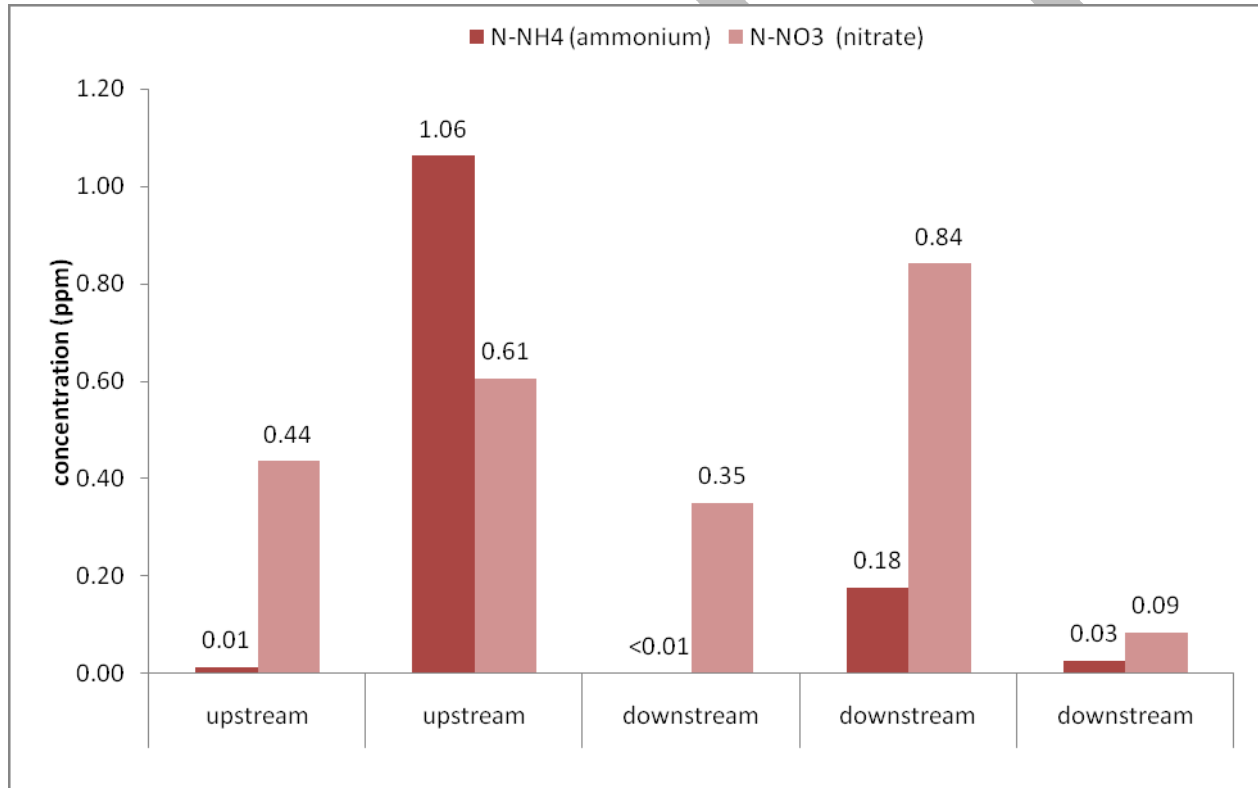


Figure 5 Concentration in parts per million of NH₄ and NO₃ at creek 2 upstream prior to (November 3) and during (November 11) a fertilization treatment. Downstream at creek 2 prior to (November 3) during (November 11) and following (November 26) a fertilization application.

Upstream concentrations of NH₄ and NO₃ spiked during the application of fertilizer. There was no sample taken on November 26. Downstream concentrations of NH₄ and NO₃ spiked during the application of fertilizer and returned to low concentrations a few weeks after treatment.

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Treatment Area 303-94

Location: Creek 2

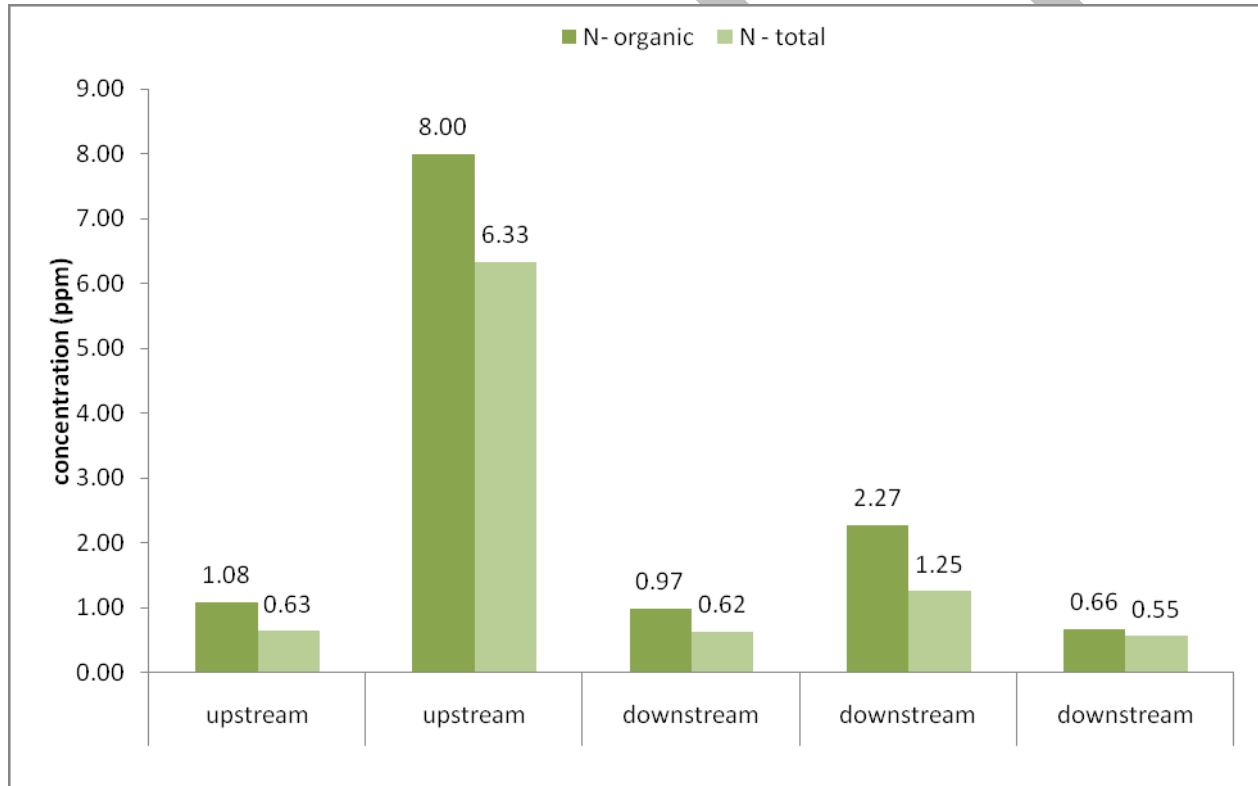


Figure 6 Concentration in parts per million of NH_4 and NO_3 in block 303-94 at upstream prior to (November 3) during (November 11) a fertilization treatment and downstream at creek 2 prior to (November 3) during (November 11) and following (November 26) a fertilization treatment

Upstream concentrations of organic nitrogen and total nitrogen spiked during the application of fertilizer. There was no sample taken (or it was poorly labelled) for November 26, 2007. Downstream concentrations of organic nitrogen and total nitrogen increased during the application of fertilizer and returned to low concentrations a few weeks later.

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Table One: Nitrate Level During and Immediately after Fertilization Treatment

Treatment Area ID	Sample Site ID	NO3 (ppm)	Time of Sample	Up or Downstream
210-589	3	0.06	post treatment	upstream
210-589	3	0.03	post treatment	downstream
210-589	3	0.02	post treatment	upstream
210-589	3	0.12	post treatment	downstream
210-589	ck1	0.06	post treatment	downstream
210-589	ck2	1.80	post treatment	downstream
210-589	l3	0.07	post treatment	
210-589	w1	0.11	post treatment	
210-589	w5	0.34	post treatment	
303-94	ck1	0.46	post treatment	upstream
303-94	ck1	0.09	post treatment	downstream
303-94	ck2	0.09	post treatment	downstream
303-94	st3	0.38	post treatment	
303-94	ck1	1.01	during treatment	downstream
303-94	ck1	1.99	during treatment	upstream
303-94	ck2	0.84	during treatment	downstream
303-94	ck2	0.61	during treatment	upstream
303-94	st3	0.03	during treatment	
409-580	3	0.21	during treatment	upstream
409-580	16	0.22	during treatment	downstream
409-580	16	0.22	during treatment	upstream
409-580	17	0.20	during treatment	upstream
409-580	1	0.02	post treatment	upstream
409-580	1	0.03	post treatment	downstream
409-580	3	0.08	post treatment	
409-657	1	0.23	during treatment	
409-657	1	0.21	post treatment	Upstream
413-587	l5	0.02	during treatment	
413-588	ck1	0.02	post treatment	Upstream
413-588	2	0.13	post treatment	Upstream
413-588	w5	0.02	during treatment	
413-588		0.30	during treatment	
413-663		0.16	post treatment	

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The table indicates that the NO₃ levels in all of the water quality samples collected during the application of fertilizer are lower than and well within the Ministry of Forest guidelines ($x < 10$ ppm) as set out in the fertilization guide book and the FIA standards.

DISCUSSION

In the introduction of the report, it was referenced that fertilizer inputs to water bodies and watercourses were not to exceed 10 parts per million. The water quality samples that were collected and analyzed indicate that this guideline was not exceeded during or after fertilizer treatment. However, Figures 2, 4 and 6 show spikes in total nitrogen and organic nitrogen, which occurred during the application of fertilizers in some waterbodies and watercourses. In consideration of seasonal variations, this may be due to other nitrogen rich materials being introduced to or present in the water bodies and watercourses. Sources of contamination such as leaves or very rich organic soils that may have been collected inadvertently as part of the water quality samples, may account for these results. This assumption is made primarily based on experience in collecting water quality samples in the field under real conditions. Depending on the depth of the water body or watercourse and the flow rate associated with the water quality sample location, organic materials and detritus, such as soil and leaves could potentially contaminate the water quality sample bottles during the collection process. This could explain the increased levels of organic nitrogen post treatment. However, it should be noted that the nitrate levels of the same water quality samples with higher reported levels of total nitrogen and organic nitrogen were relatively the same as other samples shown in chart form.

It is also noted that in some cases the data collected for the actual treatment groups could not be analyzed using the before, during and after fertilization treatment protocol due to issues with label information being lost on, before and during treatment sample bottles. It was used to record and report out actual concentrations for the post treatment time period (Table 1). These snapshots indicate that nitrate levels do not exceed the BC Ministry of Forests regulations of ($x < 10$ ppm) as set out in the Fertilization Guide Book and the FIA standards.

RECOMENDATION

Data received by the Research Branch Laboratory of the BC Ministry of Forests in Victoria was analyzed but could not be used in this report due to illegible data labels on the water quality sample bottles and in some cases, improper data labelling. In other cases, data labels that did not correspond to any other samples collected were also unable to be used in the report. It is recommended that in the future, labelling methods of water quality samples themselves and the linkage to sample locations in the field should be improved so that these problems are not encountered and all of the water quality sample data can be used for a more clear and accurate reporting of nitrate levels in water bodies and watercourses in the 2008 Fertilization Program.

Water Samples of Soluble Nitrogen Determination**CONCLUSION**

All water quality samples collected before, during and post application of the fertilizer were chemically analyzed for levels of Ammonium-N, Nitrate-N and Total N in the sample. The analysis indicated that all water quality samples analyzed are lower than and well within the Ministry of Forest Regulation "Water Quality Limits" (less than 10 ppm nitrate nitrogen in a stream immediately below the area where fertilizer has been applied). The objective of this project is to document and ensure that "Water Quality Limits" set out in the Forest Fertilization Guidebook and the Forest Investment Accounts Fertilization Standards are not exceeded by the aerial application of fertilizer during the 2007/2008 Aerial Fertilizations Project in the McLeod Lake Indian Band Traditional Territory. That has been successfully achieved and confirmed.

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